UNC-AM-12-215

ACQUISITION RESEARCH SPONSORED REPORT SERIES

Acquisition Risks in a World of Joint Capabilities: A Study of Interdependency Complexity

19 December 2012

by

Dr. Mary Maureen Brown

Department of Political Science & Public Administration

University of North Carolina Charlotte

This material is based upon work supported by the Naval Postgraduate School Acquisition Research Program under Grant No. 00244-10-1-0068

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **19 DEC 2012**	2. REPORT TYPE	3. DATES COVERED **00-00-2012 to 00-00-2012**

4. TITLE AND SUBTITLE **Acquisition Risks in a World of Joint Capabilities: A Study of Interdependency Complexity**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **University of North Carolina Charlotte,Department of Political Science & Public Administration,9201 University City Blvd,Charlotte,NC,28223**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT
Environmental uncertainty has particular ramifications for programs that seek the benefits of interdependent coordinated action. This research examined the influence of a number of interdependencies on major defense acquisition program (MDAP) performance. The analysis found that interdependencies, when defined by ?joint status,? ?number of program elements,? or ?number of data connections,? do not appear to exhibit any ill-toward effects. However, the results of the analysis illustrated that programs exert cascading influences on neighboring programs. The examination of whether MDAPs that share a program element influence each other was supported. Upstream program acquisition unit cost (PAUC) growth appeared to influence both downstream PAUC growth and downstream engineering cost variance. The upstream program?s engineering cost variance influence was mixed, demonstrating positive results in one network but negative results in the other. Upstream average procurement unit cost (APUC) growth exerted negative influences on downstream PAUC percent growth in one network and negative influences on engineering cost variance in the other network, thereby suggesting some type of economies of scale benefits. The finding that upstream PAUC growth had a consistent and positive influence on downstream PAUC growth was especially revealing. These findings illustrate that interdependent organizations are susceptible to the performance shortfalls of their partners.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**65**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

The research presented in this report was supported by the Acquisition Research Program of the Graduate School of Business & Public Policy at the Naval Postgraduate School.

Abstract

Environmental uncertainty has particular ramifications for programs that seek the benefits of interdependent coordinated action. This research examined the influence of a number of interdependencies on major defense acquisition program (MDAP) performance. The analysis found that interdependencies, when defined by “joint status,” “number of program elements,” or “number of data connections,” do not appear to exhibit any ill-toward effects.

However, the results of the analysis illustrated that programs exert cascading influences on neighboring programs. The examination of whether MDAPs that share a program element influence each other was supported. Upstream program acquisition unit cost (PAUC) growth appeared to influence both downstream PAUC growth and downstream engineering cost variance. The upstream program’s engineering cost variance influence was mixed, demonstrating positive results in one network but negative results in the other. Upstream average procurement unit cost (APUC) growth exerted negative influences on downstream PAUC percent growth in one network and negative influences on engineering cost variance in the other network, thereby suggesting some type of economies of scale benefits. The finding that upstream PAUC growth had a consistent and positive influence on downstream PAUC growth was especially revealing. These findings illustrate that interdependent organizations are susceptible to the performance shortfalls of their partners.

Keywords: Interdependent organizations, major defense acquisition program (MDAP), upstream program APUC, downstream PAUC

THIS PAGE INTENTIONALLY LEFT BLANK

About the Author

Dr. Mary Maureen Brown is a professor of public administration at the University of North Carolina–Charlotte, a senior fellow at the Center for Excellence in Municipal Management at George Washington University, and a visiting scientist at the Software Engineering Institute at Carnegie Mellon University. Brown has over 15 years of experience in cross-organizational information systems integration in government. For the past four years, she has been the principal investigator of a multimillion dollar research grant with the U.S. Department of Defense for the development and design of a program methodology for the acquisition of joint information systems. Her research interests center on participatory design, knowledge management, and joint problem solving and program planning. She has extensive experience in the design and development of various technologies for the purposes of reengineering government work processes and facilitating cross-organizational information sharing. Brown received her PhD from the University of Georgia.

Mary Maureen Brown, Ph.D.
Department of Political Science & Public Administration
University of North Carolina Charlotte
9201 University City Blvd
Charlotte, NC 28223
Tel: 704.687.4523
Fax: 704.687.1400
E-mail: marbrown@uncc.edu

THIS PAGE INTENTIONALLY LEFT BLANK

UNC-AM-12-215

ACQUISITION RESEARCH SPONSORED REPORT SERIES

Acquisition Risks in a World of Joint Capabilities: A Study of Interdependency Complexity

19 December 2012

by

Dr. Mary Maureen Brown

Department of Political Science & Public Administration

University of North Carolina Charlotte

THIS PAGE INTENTIONALLY LEFT BLANK

Table of Contents

THIS PAGE INTENTIONALLY LEFT BLANK

I. Introduction

In a world of insurgent and asymmetrical warfare, no defense organization is an island. While the Services have engaged in a host of coordinated efforts in the past, the need for situational awareness and rapid response rates demand the synergistic benefits that only wide-scale cross-integration and interoperability affords. Never in the history of the DoD has the rapid fielding of flexible and adaptive technology for countering unconventional and time-sensitive threats been more important.

This research examines DoD acquisition from the context of a network of interrelated programs that exchange and share resources for the purpose of establishing joint capabilities. The research focuses on the joint space of major defense acquisition programs (MDAPs): the space where transactions form interdependencies among MDAP programs. The research is especially salient because, to date, little is known about the risks associated with interdependent activities.

Unfortunately, by and large, the literature on interdependent activities is steeped in contradictory findings. For example, some argue that tight-knit arrangements are more likely to have the social traction needed to overcome environmental difficulties (Sosa, 2011), whereas others argue that loose coupling, or weak ties, may be a better solution (Granovetter, 1973). Some claim that more information is the key to benefit attainment (Comfort, 1994), whereas others claim that more information leads to a false sense of security (Hall, Ariss & Todorov, 2007). Yet, despite the absence of consistent sage advice, resource limitations and a demand for comprehensive solutions continue to push organizations toward complex structures for the delivery of products and services.

For this research, jointness, interdependency, exchange, and partnerships all refer to a similar concept: the notion that autonomous organizations build

relationships to obtain resources to provide capabilities that, when looked at in totality, form network structures. While it is true that at the individual pair-wise level, these exchanges exist as explicit transactions for the transfer of data, labor, capital, or materials, it is also true that the totality of the various dimensions, coupled with the turbulence of perturbations, influences the cost, schedule, and performance of the acquisition effort.

Organizations in the past sought to limit interdependencies to maintain control over the environment. More recently, however, organizations have sought to leverage the benefits that interdependencies, or partnerships, can provide. Thus, discussions of the nature of structure and how to best organize in the face of increasing needs for holistic comprehensive solutions has taken center stage. The key question seems to be whether organizations can benefit from interdependence while minimizing the negative influences of environmental turbulence. The question thus becomes, what structural arrangements and behavioral practices are conducive to achieving the benefits of coordinated actions?

This research examines the role that interdependent activities play in delivering products on time and on budget. In short, it seeks to identify the role that environmental turbulence plays in the pursuit of coordinated activities. The study of environmental uncertainty and turbulence is especially pivotal because organizations often seek to forego the benefits of partnerships, or coordinated activities, to eliminate the risk of environmental uncertainty. The following section provides a short overview on organizational interdependencies and network analysis. The discussion then segues into an examination of environmental uncertainty and adaptive capacity. The research methodology follows, and the findings of the empirical analyses are presented. While much is left to be learned, the research provides important insights on the nature of interdependent activities.

II. Interdependent Networks

A novice's glance into the field of interdependent organizational-based networks is likely to reveal a terminological jungle of abstract and obscure vocabulary. This section of the report seeks to convey many of the more common network terms and place them in the context of DoD acquisition. Table 1 provides a glossary of several of the key terms. At the onset, it is important to recognize that the term *social* is used in a specific empirical context for understanding programmatic interactions: "social systems of interaction" form the basis from which material equipment and organizational capacities get things done (Turner, 1988.

Table 1. Common Network Terms

Common Network Terms
Node: a person, team, organization, computer, etc. in a network
Tie: a connection between two nodes
Directed Network: a network where the tie is directional in nature
Undirected Network: a network where the ties are not directional
Ego: refers to the subject of the discourse
Alter: refers to the node that the ego has ties with
Ego Network: refers to the network in light of a given ego
Dyad: two nodes linked into a pair. Networks can be decomposed into their dyads, or pairs.
Structuralist Paradigm: sees the network structure as the defining characteristic of n individual node's behavior. By extension, two nodes that share structurally similar characteristics will witness similar outcomes.
Connectionist Paradigm: The focus is on the resources that flow through the ties; the ties act as conduits for the flow of resources
Diffusion: Is a measure of the spread of an innovation or characteristic throughout the network
Social Capital: The primary focus of Connectionist paradigm is primarily concerned with the resources that are gained (or lost) via the ties, and they view

success as a function of these ties.
Structural Capital: The primary focus of the Structuralist paradigm is primarily concerned with the position of nodes in a network and how this influences outcomes.
Centrality: the extent to which a given node(s) dominates the number of ties. When only a few nodes have a large number of ties compared to the others, the network is viewed as highly centralized.
Structural Equivalence: Actors (or nodes) are structurally equivalent to the extent that they are similar in their ties.
Relational Embeddedness: relates to the quality and depth of a single dyadic tie
Structural Embeddedness: relates to the extent to which a given node’s alters are interconnected
Geodesic Distance: represents how far one node is from another. It is often represented as how near or far a node is from another.
Closure : Is a measure of the number of triads (or connections among three nodes) that exist in the network
Structural Hole: A hole in the network that a node could bridge and thus act as a go-between. In this way, they can often control the two nodes that they connect.
Broker: Per the definition of *structural hole*, a broker spans two or more subnetworks.
Multiplex Ties: when a given node connects with another node in multiple networks. For example, a node may be connected to another node in both a funding network and a data-sharing network.
Homophily / Heterophily: indicates the extent to which one node is similar to another on key characteristics
Degree Distribution: the variance in the distribution of ties in a network
Network Connectivity: reflects the “size” of the network by the longest path from one node to another
Network Density: the proportion of ties in a network relative to the total number possible
Pattern of Clustering: refers to the absence or presence of subnetworks
Degree Assortativity: reflects the degree to which nodes with a similar number of ties connect with each other

Cohesion: the degree to which nodes are connected directly to each other. Under low cohesion, a number of cliques (or subnetworks) will be observed.
Bridge: a tie that is critical to the connectivity of the network. Elimination of the bridge is likely to result in a large number of factions.
Path Length: the length from one node to another. Typically measured in terms of how many nodes are in between the two.

Wasserman and Faust (1994) defined the social network perspective as a focus on the relationships that exist among entities and the patterns and implications of these relationships. Overall, the vantage point is that

- actors and their actions are viewed as interdependent rather than independent, autonomous units;
- relational ties between actors are channels for the transfer of resources; and
- network models view the structural environment as providing opportunities for, or constraints on, individual and collective action (Wasserman & Faust, 1994, pp. 3–4).

Organizations have long been viewed as resource exchanging agents. When considered in this light, each organization takes input and converts it into outputs that are then provided as inputs to another organization. Nonetheless, in the past, organizations often sought to maintain control over practices and procedures by restricting access to outside influences. Hierarchical organizational models were pursued because they provided stability. But the hierarchical approach was found to be ill-suited to situations in which needs and demands evolved. Hierarchical approaches, due to their inability to adapt, risked the obsolescence that occurred from the inability to adapt to changing needs.

Over the years, researchers have consistently found that demand uncertainty is a key contributor to the choice to forego hierarchical-based approaches in favor of organizational networks. Demand uncertainty arises when organizations lack the ability to predict near-future needs. When organizations are confronted with high levels of demand uncertainty, they require the flexibility to make rapid shifts in their

service delivery and production cycles—shifts that a hierarchical approach cannot accommodate. Because networks offer an expanded set of options, they allow the ability to respond to a wider range of contingencies. For example, under asymmetric warfare conditions, the types of solutions that may be required are difficult to predict a priori. Given the uncertainty of the demands of the battle-space, warriors require a wide arsenal of alternative and complementary approaches—approaches that must be accessible at a moment's notice. When demand uncertainty is low, organizations often choose more simplistic hierarchical approaches. Under high demand uncertainty, organizations require the ability to leverage a variety of capabilities irrespective of the boundaries of a give organization's purview (Jones, Hesterly, & Borgatti, 1997).

In the work setting, network actors (or nodes) often represent people, teams, or organizations. A tie represents some form of interaction or relationship. In short, network structures provide the "plumbing" for the flow of resources through the network.

Interdependent networks are complicated by the fact that they are multidimensional, and as such, understanding their behavior requires consideration of multiple levels of analysis. Typically, networks can be characterized in light of four basic levels: the individual, the subnetwork(s), the entire network, or as a multiplex network. A multiplex perspective considers the node from a multi-network consideration. For example, in this report, major defense acquisition program (MDAPs) are examined in light of the performance of the individual program as well as its resulting performance in two different networks: (1) a data-sharing network and (2) a shared budget network (see Figure 1).

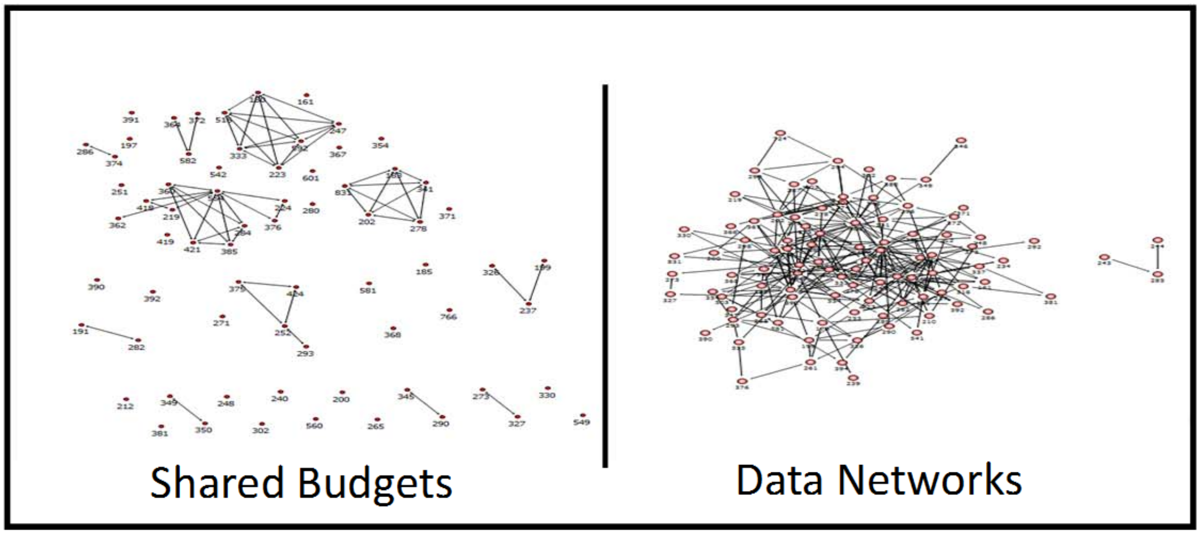


Figure 1. MDAP Networks

Cross-level effects occur when behaviors at one network level influence behaviors at another network. Cross-level analysis involves looking at behavior across the various networks. The failure to consider cross-level effects may result in misinterpreting the full set of consequences that occur from network behaviors.

At the individual (or node) level, an ego is the central node of interest, and those connected to the ego are known as alters (see Figure 2). A network rendering from the context of an ego is referred to as an ego-network. A dyad consists of an ego and its adjacent alter. As discussed further below, examining data in light of the dyads (or pairs) provides the ability to test the influence that one node has on another.

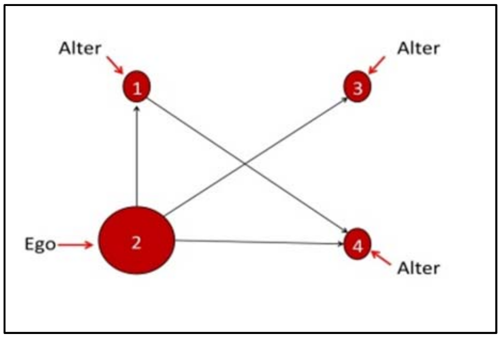


Figure 2. Ego Network

A directed network is one where the flow of resources moves in a specific direction, either inbound to an ego or outbound from an ego (see Figure 3). For example, the data-sharing network identified previously is a directed network because the data flow from one program to another. A directed network can be either sequential or reciprocal in nature. Alternatively, an undirected network is one that is “pooled” in nature. In other words, the nodes share a common connection (i.e., a budget), but there is no directional component to the tie. In this case, the tie indicates that the two programs share a common budget.

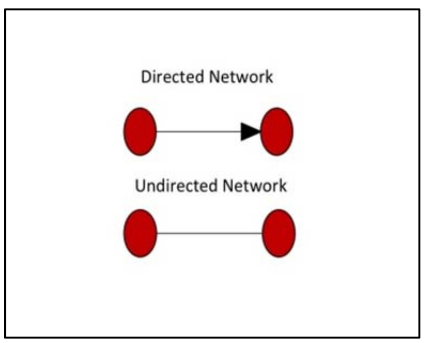


Figure 3. Directed Network and Undirected Network

A node is labeled as a broker when it connects two distinct subnetworks. So in Figure 4, Program Number 554 Multifunctional Information Distribution System Joint Tactical Radio System (MIDS JTRS) acts as a broker between three subnetworks. An isolate is a node with no ties. Again, in Figure 4, Program Number 419 (EA 6B Prowler) is an isolate. In directed networks, a node can serve as a

transmitter, a receiver, or a carrier. A bridge is identified when a tie spans two subnetworks. Structural equivalence occurs when two nodes are structurally similar (see Figure 5).

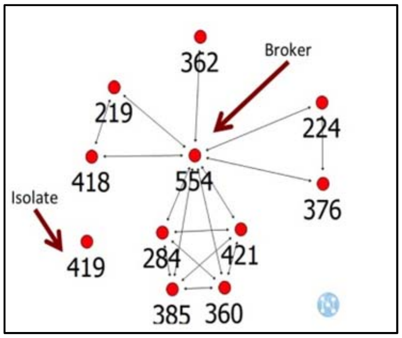


Figure 4. A Broker and an Isolate

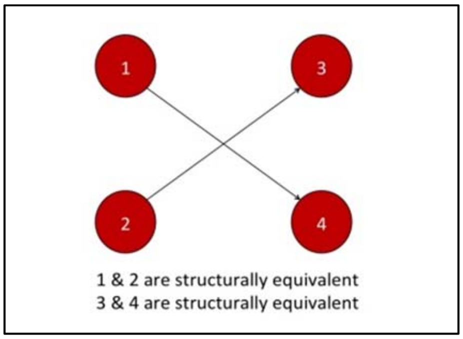


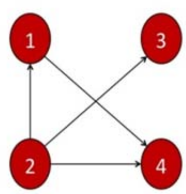
Figure 5. Structural Equivalence

Relying on matrix algebra, a number of metrics have been devised throughout the years to measure networks. Some of the metrics occur at the node or ego level, and others are at the subnetwork or whole-network levels. Nodes are often considered in light of their position, or role, in the network. Many of the ego-level metrics are calculated relative to others in the network.

The degree of a node is the number of ties that a node exhibits. These ties can be measured as inbound or outbound (or both) in a directed network. Another measure is the geodesic distance that one node may be from another. Adjacency identifies direct connections while reachability identifies whether any two nodes are

capable of connecting by way of other nodes. Degree centrality identifies the number of ties that a node possesses. The more ties relative to others, the greater the centrality. Closeness, on the other hand, indicates how close a given node is to the remaining nodes. When all of the nodes are close to all of the other nodes, the interaction level among the nodes is typically high.

Network size is often calculated as the sum of the number of nodes or number of ties (see Figure 6). Sometimes networks (or subnetworks) are measured by their longest, or shortest, path. The bridge identified previously is often of interest because it indicates that if the tie between the two nodes can be cut, the network can be disconnected or reduced to its subnetworks. The same holds true for the broker. If a broker is eliminated, the network will be reduced to a number of subnetworks. Node connectivity identifies the minimum number of nodes that have to be removed to disconnect the network. Betweenness is the extent to which a given node lies between other nodes and, thus, could act to facilitate or block the flow of resources.



Total Number of Nodes = 4
Total Number of Ties = 4
Density = #Ties/#Nodes(#Nodes-1)
Density = 4/4(4-1)
Density = 4/12 or .33

For undirected it is #ties/#nodes(#nodes-1)/2

Figure 6.

Density refers to the proportion of ties relative to the absolute total. Relational embeddedness refers to the quality and depth of a single dyadic tie. Structural embeddedness refers to the extent to which a node's alters are connected to each other. Because structural embeddedness reflects the degree of the interactions, it is often used as a proxy for understanding network actions.

In the study of networks, scholars often take either a structural or a connectionist approach. Structural approaches examine the structure of the network and its influence on key variables of interest. Connectionists, on the other hand, focus on the flows between the nodes. Those who study social capital tend to focus on the possibilities of actions that social ties provide. Others, however, tend to be more concerned with diffusion and the dynamics of network change over time. Still, other studies focus on why and how networks develop, how and why they change over time, and finally, what influences they exert. Social capital is mostly studied at the individual level, and diffusion is observed from the perspective of the entire network.

Studies of the influence of dyadic ties on performance have mixed and contradictory findings. For example, Perry-Smith and Shalley (2003) found that weak ties led to creativity, but others claim that strong ties are more advantageous (Sosa, 2011). Others claim that it is not the number of ties but rather the depth of the engagement that matters. No one would be surprised by the idea that relative to fewer ties, more ties may provide organizations with better information that might promote enhanced decision-making. At the same time, information overload and difficulties with scrubbing data to provide information at the proper specification level has become a real problem for many managers.

Similarly, studies of embeddedness are equally contradictory. According to some, the more each node knows about the others, the more constraints there are on each other's behaviors. This is often seen as a positive. Parties gather information on whom to avoid as well as potential opportunities and synergies. Structural embeddedness allows the use of sanctions since knowledge of misfeasance influences reputational value. But these constraints can backfire and actually restrict flexibility. Too much embeddedness can also create problems. It can lead to feuding, group think, and welfare support of weak members. Social aspects such as restricting access to exchanges, imposing collective sanctions, and making use of social memory and cultural processes all influence nodal behavior.

Apparently, networks and ties matter, but the extent of the influence is highly debatable.

Much of the incongruity in the findings may be due to the difficulties associated with measurement and data collection. Researchers are challenged by the burden of the data collection requirements, and organizations are often frustrated by the extent of the data request. Because multilevel data are needed for each specific relationship, the data collection task can be onerous. Moreover, given that the study of networks is a fairly new phenomenon, typical organizational records often lack insights at a network level. When multilevel data are obtained, an analysis of variance statistical technique termed *hierarchical linear modeling* or *multilevel modeling* is often employed because it allows the examination of multiple units of analysis simultaneously.

Despite these contradictory findings and data collection difficulties, the examination of networks and ties that manifest as interdependencies is likely to provide substantial insights into a number of issues. First, when considering cost and affordability, examining a program in isolation of the entire value chain is likely to provide erroneous information. Second, a wealth of research illustrates the importance of risk management. Considering the risks of a given program without considering its interdependencies may underestimate the true risk level. Next, in the decision of a start-up or termination, it is essential to know how the inclusion or removal of a program will influence its n-order neighbors. Finally, network conditions may exert powerful influences over program sustainability.

The following discussion explores the issue of environmental uncertainty and its potential effects on network performance. As mentioned, under demand uncertainty, network forms of organization appear attractive. However, they also expose the organization to the uncertainties associated with environmental turbulence: the very influence that hierarchical organizations sought to eliminate.

A. Environmental Uncertainty

Over half a century ago, scholars noted that organizations were not immune to the uncertainty of shifting environmental conditions. Thompson (1967), March and Simon (1958) all wrote extensively about the role of the environment on organizational performance. The general concern was that environmental turbulence created an inability to accurately predict resource shifts, thereby leaving the organization at risk. Others identified that it was not necessarily the rate of change, or the degree of the change, that created the problem as much as it was the unpredictability of the change that created the greatest turmoil (Lawrence & Lorsch, 1973; Miles, Snow, & Pfeffer, 1974; Milliken, 1987). Apparently, disruptive events surface in the way of “shifts,” “steady turbulence,” and “jolts.” All three of these occurrences demand adjustments and adaptation.

Milliken’s (1987) work illustrated that there are at least three different types of uncertainty: state, response, and effect. He defined *state uncertainty* as “the situation that occurs when managers do not feel confident that they understand what the major events or trends in an environment are or feel unable to accurately assign probabilities to the likelihood that particular events or changes will occur.” Conversely, response uncertainty characterizes an inability to predict the likely consequences of a given choice. Effect uncertainty is characterized by an inability to predict the nature of the effect on the organization’s future state.

Most of the research suggested that organizations take deliberate, intentional, and rational steps to eliminate environmental flux and to regain equilibrium. In 1969, Herbert Simon identified that organizations rely on three different modes to regain stability: passive insulation, reactive negative feedback, and predictive adaptation. Thompson (1967) argued that organizations used “buffering” techniques such as rational planning, standard operating procedures, industry standards, and contracts to minimize flux. All of these behaviors seek to absorb environmental uncertainty. Thompson’s (1967) research found that organizations attempt to buffer the technical core from outside disturbances … and if it fails, they try to make adjustments to the

technical core to regain equilibrium. Where buffering seeks to absorb environmental fluctuation, smoothing or leveling seeks to reduce fluctuations in the environment. Smoothing involves active intervention by the organization to stabilize the environment, and Cyert and March (1963) called attention to the importance of slack resources in protecting the organization from environmental flux.

Milliken (1987) argued that the most effective strategies for dealing with environmental turbulence depend on the type of uncertainty. Whether the uncertainty is rooted in state, effects, or response may mandate different approaches to buffering and the type of slack resources required to maintain stability in the face of turbulence.

For an organization that wishes to maintain stability, Miles and Snow (1978) recommended an organizational structure that focused on functional divisions, centralized control, long-looped vertical information systems, and conflict resolution via hierarchical channels. For organizations that wish to promote flexibility, they recommended low division of labor, decentralized control, short-looped horizontal information systems, and resolution through integrators.

More recently, scholars have called attention to the ill-toward effects of strategies that promote stability via isolation strategies. They claimed that isolating the organization from the environment can lead to diminished capacities. With this realization came the knowledge that agencies that were capable of improving performance by leveraging external resources, while also protecting themselves from the turbulence of uncertainty, realized substantial performance gains.

Following this thread, others found that organizations actually interacted with the environment in a manner to gain power, manipulate, and control the environment. In other words, they anticipated flux and reacted prior to its occurrence. In this way, they attempted to head off the uncertainty, thus the finding that “anticipatory” organizations are capable of creating their own future state. This idea that organizations anticipate environmental threats and act accordingly is

important in the network setting. As discussed further below, anticipatory activities may perturb neighbors. Despite all the research, the question that Ansoff posed in 1979 remains valid: How do we configure the resources of the firm for effective response to unanticipated surprises? He pointed out that the "strategy of structure" had largely been ignored. In many ways, his question, while not ignored, remains unanswered.

B. Adaptive Capacity

Much of the literature has focused on an organization's adaptation capabilities to changing environmental conditions. Under stable conditions, organizational partners can establish mutually acceptable arrangements. Recall that under stable environmental conditions, organizations can also rely on hierarchical organizational structures. Rather, in the face of demand uncertainty and environmental flux, organizations demand flexibility, or the ability to adapt to the stimuli. Oftentimes, these adaptations perturb external relationships that then set off feedback loops to accommodate to the changes. As an example, program managers establish multi-year financial forecasts on how much money they will receive from Congress for their program. When an unexpected shortfall occurs, the program must scale back. In a network context, not only does the scale-back influence the individual program, but it could also influence all of the program's partners, causing them to have to accommodate for their partner's shortfall. In the acquisition arena, in which programs are interdependent, the inability to accurately predict future state, effect, and response needs can manifest in cost, schedule, and performance fluctuations.

Apparently, an organization's capacity to address environmental uncertainty depends on the absorptive capacity of its members (Cohen & Levinthal, p. 131). By 1990, Cohen and Levinthal had refined some of their thinking and argued that an organization's absorptive capacity is not resident in any single individual but depends on the link across a mosaic of individual capabilities that are often internalized via routines, histories and stories, documentation, procedures, and know-how (Grant, 1996). Long-term survival is contingent on the ability to sustain

creative and innovative behaviors in a network of interdependencies. Stacey (2002) called for the need to establish spontaneous changeability—downward and upward spirals in which feedback loops act to amplify existing behaviors.

Comfort's (1994) work indicated that organizations can be quite successful at rearranging and reforming configurations of operation in mutual adaptation to the changing needs and capacities of their environmental components. She found that organizations were capable of mutually adapting to the changing demands and opportunities imposed by the environment. The distinguishing characteristic of this process is that it occurs as a result of communication, selection, and adaptation processes within the system itself and between the evolving system and its environment (Comfort, 1994; Kaufmann, 1993).

In considering interdependent organizations, Levinthal (1997) argued that each individual's payoff function depended on the choices that other external actors make, so each individual's adaptive landscape—the mapping of behavior to realized outcomes—is constantly shifting. In this way, interdependencies form complex adaptive systems that evolve over time through the entry, exit, and transformation of other actors. Because the linkages evolve over time, the configuration and strength of the interconnections is in constant flux. Closely tied to the concept of bounded rationality (March & Simon, 1958), because of an inability to forecast system-level consequences, individuals optimize for their own gain rather than that of the collective network. Kauffman's (1993) adaptive landscape metaphor (borrowed from Wright, 1931) suggested that organizations co-evolve on a fitness landscape to a state poised between order and chaos. The landscape on which actors adapt continually shifts because the payoffs of individual agents depend on the choices that other actors make (Levinthal, 1997, McPherson & Ranger-Moore, 1991).

C. Complexity

Complex adaptive systems, when defined by interdependent relationship structures, are often examined in terms of their ability to adapt to changes in the

environment. The adaptation can take a variety of forms, from immobility on one extreme to chaos on the other. A static or immobile state reflects the inability of the relationship to adapt the necessary policies, procedures, or activities to address environmental perturbations. Conversely, the chaotic state represents a hyper-turbulent response to environmental flux. An understanding of the adaptation configurations of these complex relationships carries important implications for management. Goals and objectives as well as capital and opportunity costs are inherently tied to potential activities of adaptation.

The study of adaptive behaviors has led many to argue that organizations never achieve equilibrium, and thus, they investigate behavior from a nonlinear and dynamic perspective. The recognition of the existence of network externalities signifies a growth in organizational complexity. How to deal with the complexity is another matter. Apparently, managers can choose to absorb the complexity, reduce the complexity, or discard the complexity. Their choice is thought to be a result of how they frame and label the complexity. Interestingly enough, a recent speech by Mr. Gary Bliss on Root Cause Analysis identified that much of the failure of programs to be delivered on time, on cost, and at the desired performance level is due to incorrect framing of the initiative at the outset. Managers discard or avoid complexity oftentimes when information is ambiguous or prone to diverse interpretations. Yet, others argue that the hectic, multitasking world has led to collective attention deficit disorder. In networks, information asymmetries can be a powerful force that leads to group dysfunctions including self-silencing, error amplification, and group-think.

Unfortunately, previous research has also illustrated that adaptive behaviors can cascade in unexpected ways and thus, can have a tremendous impact on the achievement of critical goals and the final costs associated with any organizational activity. Despite Cohen and Levinthal's (1990) seminal article some 20 years ago on absorptive capacity, scholars argued that the "emergence of absorptive capacity from the actions and interactions of individual, organizational, and interorganizational

antecedents remain unclear" (Volberda, Foss, & Lyles, 2010). Scholars and practitioners alike quickly identified that the complexity associated with a given objective wrested in the actual links that tied the organizations together. They also discovered that as individual organizations sought to change their procedures to circumvent environmental flux, they actually created instability for others.

D. Cost and Performance

Given the overt focus on network relations, transaction cost economics dovetails quite nicely with network theory because it is primarily concerned with the costs that arise from the exchange of resources. In the economics arena, the point where the transaction, or hand-off, occurs has not been considered a cost—the reason being that the "buyer" saw a return on investment, else they would defect or leave the relationship. Other research has argued that some asymmetries may abound, thus leading to some iniquities. However, it has been widely held that these iniquities are minimal at best. More recently, however, these assumptions have been challenged. Apparently, whether the ties are technological or social (and most times, they are both), transaction costs will accrue.

According to Williamson (1981), transaction costs arise from (1) bounded rationality, (2) asset specificity, and (3) opportunism. The lifeblood of interdependent activities is coordination. The more ties, the greater the coordination demands. Hence, Jones et al. (1997) claim that networks exist via a complicated dance of mutual adjustment and communication (p. 916). High adaptation and coordination needs tend to trigger safeguarding. In other words, agency behaviors arise. With a need to prioritize individual interests, conscious agency, or self-serving, activity is not unexpected. Network nodes also experience differential, and unbalanced, advantages and disadvantages. Thus, ties are often created, dissolved, or modified in terms of their strength or content as conditions change.

In trying to determine absolute cost, the determination of the true value chain becomes increasingly difficult. Supply chain management has focused primarily on

vertical chains, thus leading to wide gaps in understanding the cost of horizontal relationships. Theoretically, joint capabilities should provide significant defense advantages. From the battlefield perspective, joint capabilities should promote greater situational awareness and thus reduce the risk of fratricide (i.e., “friendly fire”). An improved understanding of the location of various Service resources should also allow battlefield commanders to tap a wider range of arsenal assets. From a support perspective, joint capabilities should allow support agencies to improve their understanding of where various resources are located and how to leverage them to assist battlefield operations. Furthermore, from a command perspective, joint capabilities should improve understanding of the available resources that can be leveraged and enable a greater understanding of how to mitigate enemy threats.

Yet, little is known about the cost or the risk that organizations encounter in these highly interdependent complex structures. For the most part, the research is anecdotal at best and in search of a theoretical framework. This research seeks to examine the influence of interdependencies on program performance. In short, it seeks to address Ansoff’s (1979) question.

THIS PAGE INTENTIONALLY LEFT BLANK

III. Research Questions

In summary, the demand uncertainty of current defense threats has triggered a need to establish a battlefield in which resources are plentiful and available in a timely manner. These needs require a transformation in how acquisition efforts have transpired in the past. Acquisition efforts must now incorporate the network capabilities that are capable of serving the warfighter.

Network approaches require a fundamental shift in how organizational performance has been understood in the past. It requires new appreciation for environmental uncertainty, adaptability, cost, performance, and sustainability. This research seeks to identify the influence that interdependent activities exert on program performance. The research seeks to

1. identify and characterize the nature of MDAP interdependencies;
2. test to see if program cost correlates with any of the interdependency characteristics;
3. isolate the extent to which acquisition performance breaches (i.e., per unit cost growth, schedule delays, and feature shortfalls) in an upstream program cascade to downstream interdependent MDAP programs; and
4. compute overall annual MDAP network metrics of complexity dating back to 2005 to see how they might relate to the total acquisition spending.

THIS PAGE INTENTIONALLY LEFT BLANK

IV. Research Methods

The sample for the research was all active major defense acquisition programs (MDAPs) between the 2005–2011 time period. The data for the analysis are derived from select acquisition reports (SAR) and defense acquisition executive summary (DAES) reports.

Two major sets of analyses were employed to meet the research objectives. First, the research tested to see whether interdependence influenced an MDAP's cost or schedule performance. In this way, the MDAPs were considered from an "ego" individual-level perspective (see pages 3 and 8). Interdependency was measured in three ways. The first was a count of the number of program elements that funded the MDAP. The number of program elements that funded an MDAP was used as a proxy for budget interdependence. The second interdependency captures the number of data connections that characterizes an MDAP. In the DAES report, at the start of the program, managers were asked to identify all of the critical external data interdependencies. The data connection variable is a count of the external data interdependencies. The third interdependency variable is measured as a dummy variable that indicates whether a given program is deemed officially "joint" by the DoD. These three types of interdependencies are examined as follows for their influence on individual program performance. Per the preceding discussion, these variables provide an indicator of structural embeddedness.

The second set of questions related to perturbations or cascading effects. Because the shared budget network and the data-sharing network was captured at the individual program level, network renderings could be obtained for each year under study. Employing a dyadic analysis data structure, each program was tested for a cascading effect. In short, it is not uncommon for a program to have a number of different types of interdependencies and, thus, the need to consider program performance from multiple interdependency dimensions. The appendix shows the

evolution of the shared budget network over time. The data flow network was considered stable over time.

Several control variables were incorporated into the analysis: development estimate (proxy for size), program stage (proxy for age), the previous year's growth rate (proxy for past performance), and finally, a variable to capture variance over time. These variables were included in the models because they were seen as potentially influencing the program's performance.

Five performance-based variables served as the dependent variables:

1. annual percent unit cost growth from the previous year,
2. annual percent procurement cost growth from the previous year,
3. annual percent engineering cost variance from the previous year,
4. annual percent estimation cost variance from the previous year, and
5. annual percent schedule cost variance from the previous year.

The cost variance metrics were tested because they are often monitored as a risk indicator. The results of the analyses are presented as follows. Multilevel mixed modeling was the technique of first choice. However, the between subject variance was basically zero so ordinary least squares was employed.

Table 2 provides the mean and standard deviations for each variable employed in the study. In short, 16% of the programs were considered joint and 57% of the programs were in production. The annual average procurement unit cost (APUC) overrun was 7%, and the average annual program acquisition unit cost (PAUC) overrun was 29%.

Table 2. Descriptive Statistics of Key Variables

Descriptive Statistics of Key Variables					
	N	Min	Max	Mean	Std. Deviation
Number of Program Elements	865	0	33.00	2.46	3.47
Pct APUC Growth	456	-57.41	1108.94	6.53	56.70
Pct PAUC growth	501	-57.22	10146.15	29.23	458.23
Number of Data Connections	865	101	831.00	341.59	137.26
Development Estimate	477	183.76	178478.70	12158.75	23109.00
Percent Engineering Cost Variance	578	-9.84	17.57	0.15	1.35
Percent Estimating Cost Variance	578	-47.65	48.61	0.33	3.74
Percent Schedule Cost Variance	578	-17.11	8.51	0.03	1.05
Number of Programs Sharing a Budget With	865	0	19.00	0.86	2.10

THIS PAGE INTENTIONALLY LEFT BLANK

V. Findings

A. Individual Level Effects

Per Tables 3-7, only one of the interdependency variables illustrated significance and with only one of the dependent variables. Number of program elements influenced engineering cost variance in a positive direction. Hence, the greater the number of program elements, the greater the engineering cost variance.

Three other relationships were also noted. PAUC and APUC growth appeared related, and the previous year's percent estimating cost variance appeared to be related to both estimating cost variance and schedule cost variance.

Table 3. Dependent Variable: Pct PAUC Growth

Dependent Variable: Pct PAUC Growth			
Adj R Square	Unstandardized Coefficients	Standardized Coefficients	Sig.
.360	B	Beta	
(Constant)	4.771		.674
Number of Data Connections	-.503	-.027	.605
Number of Program Elements	-.071	-.003	.959
Joint Status	-4.916	-.024	.628
Previous Year's Pct PAUC Growth	.209	.046	.315
Pct APUC Growth	.802	.613	.000
Pct Engineering Cost Variance	-.154	-.003	.953
Pct Estimating Cost Variance	.808	.024	.608
Pct Schedule Cost Variance	-.081	-.001	.991
Development Estimate	.000	-.003	.962
Stage	-3.362	-.019	.689
Year 2006	17.559	.082	.141
Year 2009	-.260	-.001	.982
Year 2010	-.385	-.002	.974
Year 2011	11.449	.052	.344

Table 4. Dependent Variable: Pct APUC Growth

Dependent Variable: Pct APUC Growth			
Adj R Square	Unstandardized Coefficients	Standardized Coefficients	Sig.
.360	B	Beta	
(Constant)	6.722		.450
Number of Data Connections	.020	.001	.979
Number of Program Elements	-.072	-.004	.947
Joint Status	-.137	-.001	.986
Previous Year's APUC Growth	-.008	-.002	.959
Pct PAUC Growth	.462	.606	.000
Pct Engineering Cost Variance	.203	.005	.921
Pct Estimating Cost Variance	-1.915	-.074	.120
Pct Schedule Cost Variance	-1.469	-.013	.783
Development Estimate	.000	-.016	.765
Stage	-7.035	-.052	.284
Year 2006	-5.646	-.034	.549
Year 2009	4.116	.025	.657
Year 2010	13.523	.084	.142
Year 2011	-4.365	-.026	.647

Table 5. Dependent Variable: Pct Engineering Cost Variance

Dependent Variable: Pct Engineering Cost Variance			
Adj R Square	Unstandardized Coefficients	Standardized Coefficients	Sig.
.016	B	Beta	
(Constant)	-.113		.642
Number of Data Connections	.015	.050	.429
Number of Program Elements	.085	.194	.002
Joint Status	.071	.021	.726
lagPct Engineering Cost Variance	-.005	-.004	.937
Pct PAUC Growth	.000	-.021	.759
Pct APUC Growth	.000	.009	.899
Pct Estimating Cost Variance	.034	.068	.226
Pct Schedule Cost Variance	-.051	-.023	.686
Development Estimate	.000	-.140	.028
Stage	-.033	-.012	.837
Year 2005	.041	.010	.883
Year 2006	.323	.085	.213
Year 2007	-.128	-.036	.599
Year 2009	-.001	.000	.996
Year 2011	.243	.067	.330

Table 6. Dependent Variable: Pct Estimating Cost Variance

Dependent Variable: Pct Estimating Cost Variance			
Adj R Square	Unstandardized Coefficients	Standardized Coefficients	Sig.
.059	B	Beta	
(Constant)	1.187		.023
Number of Data Connections	-.006	-.009	.885
Number of Program Elements	-.032	-.040	.579
Joint Status	-.066	-.011	.875
Previous Year's Pct Estimating Cost Variance	.179	.206	.001
Pct PAUC Growth	.001	.035	.645
Pct APUC Growth	-.005	-.130	.090
Pct Engineering Cost Variance	.217	.127	.046
Pct Schedule Cost Variance	.159	.037	.544
Development Estimate	.000	-.001	.989
Stage	-.665	-.116	.068
Year 2005	-.520	-.040	.542
Year 2006	-.996	-.133	.071
Year 2007	-.315	-.047	.532
Year 2009	.539	.083	.268
Year 2011	-.843	-.127	.088

Table 7. Dependent Variable: Pct Schedule Cost Variance

Dependent Variable: Pct Schedule Cost Variance			
Adj R Square	Unstandardized Coefficients	Standardized Coefficients	Sig.
.028	B	Beta	
(Constant)	.191		.043
Number of Data Connections	-.007	-.054	.383
Number of Program Elements	-.002	-.012	.846
Joint Status	.024	.017	.775
Previous Year's Pct Schedule Cost Variance	.031	.030	.568
Pct PAUC Growth	.000	-.036	.592
Pct APUC Growth	.001	.078	.239
Pct Engineering Cost Variance	-.009	-.021	.691
Pct Estimating Cost Variance	.049	.225	.000
Development Estimate	.000	-.009	.889
Stage	-.084	-.069	.203
Year 2005	-.026	-.015	.811
Year 2006	-.086	-.055	.408
Year 2009	-.029	-.019	.777
Year 2010	-.073	-.048	.473
Year 2011	-.053	-.033	.613

B. Cascades

The second set of models sought to isolate the extent to which interdependent MDAPs influence each other's growth rate. This set of tests sought to isolate whether the upstream program's growth influenced their first order downstream counterpart. As mentioned previously, two networks are tested: a data connection network and a shared budget network. The data network is a sequential network in that it shows the direction of the data transfer. Thus, the analysis could

determine how upstream programs exhibited influences on downstream nearest neighbors.

The budget network was an undirected network. A network rendering of the MDAP–program element relationship discussed previously provided the ability to identify all of the programs that a given MDAP shared a budget with. Hence, the programs share a budget-level interdependency. The budget network is an example of what Thompson (1967) referred to as a “pooled” relationship, meaning that the network shows the programs that are interconnected via a shared budget; there is no direction to the tie or link. So the analysis sought to determine the following: if one program had cost growth, would it cascade to the shared budget neighbors? The cascades were tested on the five dependent variables of interest while also controlling for key program characteristics.

To determine the effect of the cascade, several variables were included in the model as controls. Because the goal was to see how upstream programs influence their downstream counterparts, controlling for factors that might influence the downstream program’s growth rate became imperative. Consequently, the following controls were added to the model: number of data connections, number of programs with shared budgets, joint status, previous year’s growth, and development estimate.

Five key upstream influences were tested for influencing the downstream program performance in both the data and budget networks:

1. upstream percent PAUC growth,
2. upstream percent APUC growth,
3. upstream percent engineering cost variance,
4. upstream percent estimating cost variance, and
5. upstream percent schedule cost variance.

Table 8 provides the results of the analysis. Note that the data and budget network results are adjacent in the table.

Table 8. Interdependency Cascades

	Data Network				Shared Budget Network		
	Dependent Variable: Downstream Pct PAUC Growth						
Adj R Square	.162				.158		
	B	Beta	Sig.		B	BBeta	Sig.
(Constant)	24.585		.83		-173.60		.24
Downstream Number of Data Connections	28.84	.15	.000		41.61	.22	.000
Downstream Number of Program Elements	-29.52	-.10	.01		-22.97	-.123	.09
Downstream Joint Status	401.60	.16	.000		284.04	.131	.09
Downstream Prev Year Pct PAUC Growth	-3.66	-.03	.29		-5.261	-.059	.27
Upstream Pct PAUC Growth	2.45	.137	.009		27.40	.28	.003
Upstream Pct APUC Growth	-1.94	-.020	.703		-19.23	-.18	.044
Upstream Pct Eng Cost Variance	-132.69	-.106	.002		105.06	.17	.001
Upstream Pct Est Cost Variance	-16.26	-.02	.52		-60.38	-.10	.061
Upstream Pct Schedule Cost Variance	-128.10	-.03	.34		-43.01	-.02	.68
Downstream Development Estimate	-.004	-.101	.010		.002	.03	.55
Stage	-178.79	-.07	.04		-61.88	-.03	.56
Year 2006	-22.20	-.008	.85		-26.49	-.01	.87
Year 2009	14.97	.005	.898		-21.66	-.009	.880
Year 2010	-4.00	-.001	.973		77.45	.031	.604
Year 2011	827.96	.258	.000		466.39	.175	.004

	Data Network			Shared Budget Network		
	Dependent Variable: Downstream Pct APUC Growth					
Adj R Square	.061			.079		
	B	Beta	Sig.	B	Beta	Sig.
(Constant)	5.718		.004	4.221		.111
Downstream Number of Data Connections	.144	.049	.301	.313	.086	.139
Downstream Number of Program Elements	-.813	-.192	.000	-.295	-.08	.293
Downstream Joint Status	-1.323	-.034	.504	-7.608	-.19	.026
Downstream Previous Year's Pct APUC Growth	-.058	-.059	.131	-.018	-.02	.703
Upstream Pct PAUC Growth	.011	.031	.584	.006	.00	.964
Upstream Pct APUC Growth	-.099	-.068	.239	-.054	-.05	.395
Upstream Pct Eng Cost Variance	1.547	.047	.222	-1.697	-.09	.097
Upstream Pct Est Cost Variance	.171	.015	.704	.077	.008	.898
Upstream Pct Schedule Cost Variance	.598	.010	.802	4.646	.066	.249
Downstream Development Estimate	.000	.044	.312	.000	.030	.630
Stage	-3.307	-.092	.028	-1.501	-.04	.438
Year 2005	-6.177	-.102	.018	-13.46	-.22	.000
Year 2006	1.751	.038	..407	-3.09	-.067	.313
Year 2009	2.328	.054	..252	-2.05	-.052	.432
Year 2010	1.857	.041	..374	-.86	-.019	.768
Year 2011	-1.27	-.02	..607	-3.20	..066	.293

	Data Network			Shared Budget Network		
	Dependent Variable: Downstream Pct Engineering Cost Variance					
Adj R Square	.134			.217		
	B	Beta	Sig.	B	Beta	Sig.
(Constant)	-.212		.330	-.277		.177
Downstream Number of Data Connections	-.008	-.023	.598	-.023	-.078	.138
Downstream Number of Program Elements	.075	.155	.000	.114	.399	.000
Downstream Joint Status	.001	.000	.994	.131	.040	.567
Downstream Previous Year's Pct Engineering	-.024	-.021	.573	-.095	-.042	.414
Upstream Pct PAUC Growth	.004	.147	.004	-.004	-.029	.607
Upstream Pct APUC Growth	-.016	-.101	.050	.000	.001	.988
Upstream Pct Eng Cost Variance	.408	.209	.000	-.034	-.042	.405
Upstream Pct Est Cost Variance	-.026	-.021	.574	-.104	-.113	.027
Upstream Pct Schedule Cost Variance	-.224	-.033	.363	-.377	-.059	.227
Downstream Development Estimate	.000	-.092	.021	.000	-.072	.184
Stage	.299	.075	.056	.153	.053	.319
Year 2005	.106	.017	.691	.041	.008	.886
Year 2006	1.135	.189	.000	.251	.056	.322
Year 2007	-.086	-.017	.699	-.085	-.022	.694
Year 2009	-.026	-.006	.900	-.055	-.014	.798
Year 2011	.756	.132	.002	.728	.180	.002

	Data Network			Shared Budget Network		
	Dependent Variable: Downstream Pct Estimating Cost Variance					
Adj R Square	.148			.039		
	B	Beta	Sig.	B	Beta	Sig.
(Constant)	.759		.020	.788		.008
Downstream Number of Data Connections	-.040	-.093	.052	.031	.101	.135
Downstream Number of Program Elements	-.026	-.044	.372	-.029	-.103	.234
Downstream Joint Status	.167	.030	.562	.450	.134	.153
Downstream Previous Year's Pct Estimating	.293	.311	.000	.027	.037	.577
Upstream Pct PAUC Growth	.001	.026	.677	-.008	-.056	.586
Upstream Pct APUC Growth	-.010	-.049	.433	.010	.064	.540
Upstream Pct Eng Cost Variance	.040	.017	.675	-.095	-.110	.089
Upstream Pct Est Cost Variance	.034	.020	.632	-.015	-.015	.827
Upstream Pct Schedule Cost Variance	.503	.063	.117	.664	.107	.087
Downstream Development Estimate	.000	-.011	.800	.000	-.057	.411
Stage	-.478	-.089	.042	-.257	-.078	.275
Year 2005	.120	.005	.912	-.672	-.082	.228
Year 2006	-.294	-.038	.434	-.719	-.130	.070
Year 2007	-.175	-.028	.573	-.530	-.129	.070
Year 2009	1.574	.268	.000	-.340	-.079	.282
Year 2011	-.099	-.014	.771	-.613	-.153	.041

	Data Network			Shared Budget Network		
	Dependent Variable: Downstream Pct Schedule Cost Variance					
Adj R Square	.018			-.016		
	B	Beta	Sig.	B	Beta	Sig.
(Constant)	.136		.008	.136		.071
Downstream Number of Data Connections	-.003	-.035	.436	-.001	-.006	.916
Downstream Number of Program Elements	.003	.026	.561	.006	.065	.383
Downstream Joint Status	-.028	-.027	.568	-.125	-.123	.113
Downstream Previous Year's Pct Schedule	.116	.110	.003	.028	.037	.497
Upstream Pct PAUC Growth	.000	-.036	.482	.001	.028	.655
Upstream Pct APUC Growth	.000	.011	.833	.000	.004	.951
Upstream Pct Eng Cost Variance	-.018	-.037	.315	.012	.044	.424
Upstream Pct Est Cost Variance	.002	.008	.836	.004	.013	.821
Upstream Pct Schedule Cost Variance	-.049	-.029	.425	-.011	-.010	.848
Downstream Development Estimate	.000	-.050	.215	.000	-.092	.125
Stage	-.112	-.117	.003	-.109	-.116	.049
Year 2005	-.037	-.024	.560	-.019	-.012	.841
Year 2006	.011	.008	.846	.002	.001	.985
Year 2009	.043	.037	.414	.072	.061	.340
Year 2010	.085	.073	.103	.002	.002	.978
Year 2011	.029	.020	.638	-.016	-.012	.846

In both the data and budget networks, upstream percent PAUC growth illustrated a positive influence on downstream percent PAUC growth. Upstream

percent PAUC growth also yielded a positive influence on downstream engineering cost variance for the data network.

Upstream percent APUC growth exerted a negative influence on downstream PAUC percent growth in the budget network and downstream engineering cost variance in the data network.

Upstream percent engineering cost variance had a negative influence on downstream percent PAUC growth in the data network but a positive influence in the budget network. It also exerted a positive influence on downstream percent engineering cost variance in the data network.

Upstream percent estimation cost variance and schedule cost variance illustrated no relationships with any of the models. A number of the control variables also illustrated statistical significance. In these models, the interdependency variables were significant predictors of unit growth. The number of data connections and joint status was related to unit growth in a positive direction. The number of data connections was also positive and significant in the shared budget network. In the data network, the number of program elements was significant on unit cost growth but in a negative direction.

On procurement cost growth, the number of program elements had a negative influence in the data network and joint status had a negative influence on procurement growth in the shared budget network. Stage (0 = development; 1= production) was significant in a negative direction in every model. Hence, as programs move from development to production, they experience less ill-toward growth. The previous year's percent estimating cost variance was predictive of the current year's estimating cost variance as was the previous year's schedule cost variance on the current year's schedule cost variance.

C. Conclusion

Network-based organizations are proving more pivotal in situations where demand uncertainty runs high. Despite the fact that they are occurring with greater frequency, their influence on program performance remains unknown. Of utmost concern is the adaptive needs that accompany interdependent organizations. Theoretically, interdependence may yield high levels of environmental uncertainty for unsuspecting interconnected programs. The environmental uncertainty is likely to reveal itself in the way of unanticipated cost growth.

This research examined the influence of a number of interdependencies on program performance. The issue of environmental turbulence was central to the research. The analysis looked at all active MDAPs during the 2005–2011 time frame. It found that interdependencies (when defined by “joint status,” “number of program elements,” or “number of data connections”) do not appear to exhibit any ill-toward effects on the individual program. In short, outside of the influence of the number of program elements on engineering cost variance, none of the interdependency variables appeared to influence the individual program’s performance.

The same does not hold for the cascades. Upstream unit cost growth had a significant and positive influence over the downstream program’s unit growth. Interestingly, the upstream’s engineering cost variance demonstrated a negative influence on downstream unit cost in the data network but it reversed itself in the shared budget network, demonstrating a significant positive relationship. Similar results held when examining the downstream program’s engineering cost variance.

The findings are particularly noteworthy because they show the influence of interdependencies in two types of networks: a sequential data network and a pooled budget network. By the sheer number of positive relationships to cost or cost variance growth, the sequential data network illustrated greater susceptibility than its shared budget network counterpart. The fact that the interdependencies exhibit

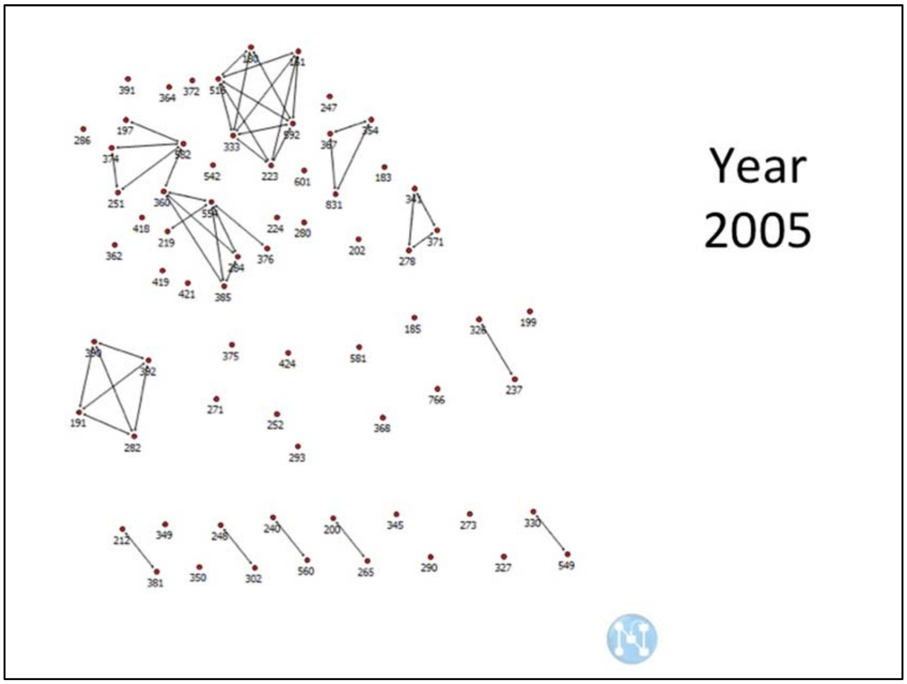
effects on unit cost growth and engineering cost variance for both networks is particularly troubling. DoD programs are under increasing pressure to reduce cost growth, much of which occurs due to changes in the engineering arena.

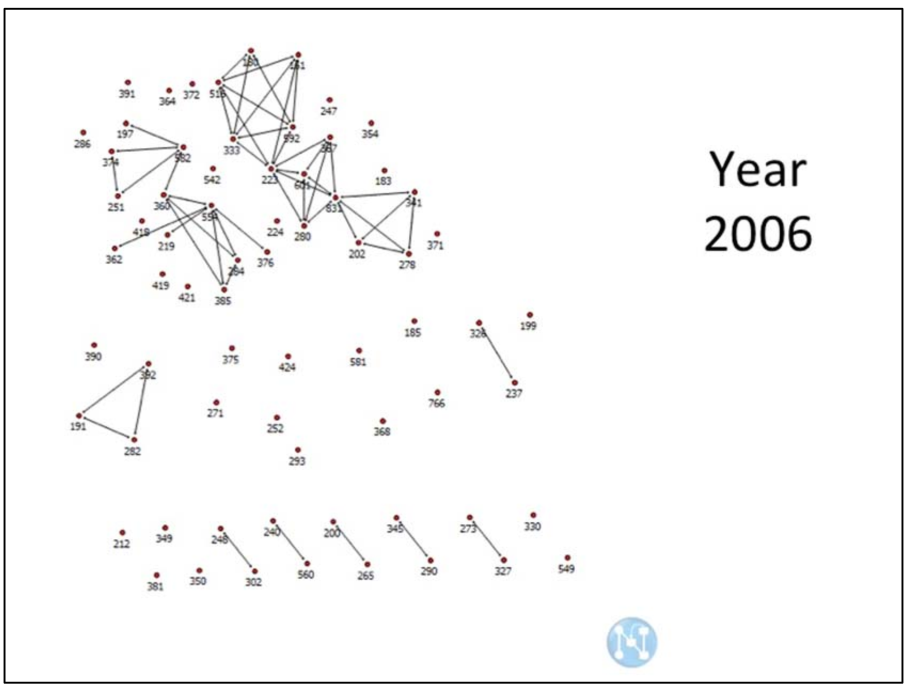
Also of interest is the finding that joint status only appears to influence downstream unit growth. The fact that the number of program elements was negatively related to both unit cost and procurement cost is intriguing. This signal may illustrate that some sort of economies of scale are being witnessed through the arrangement.

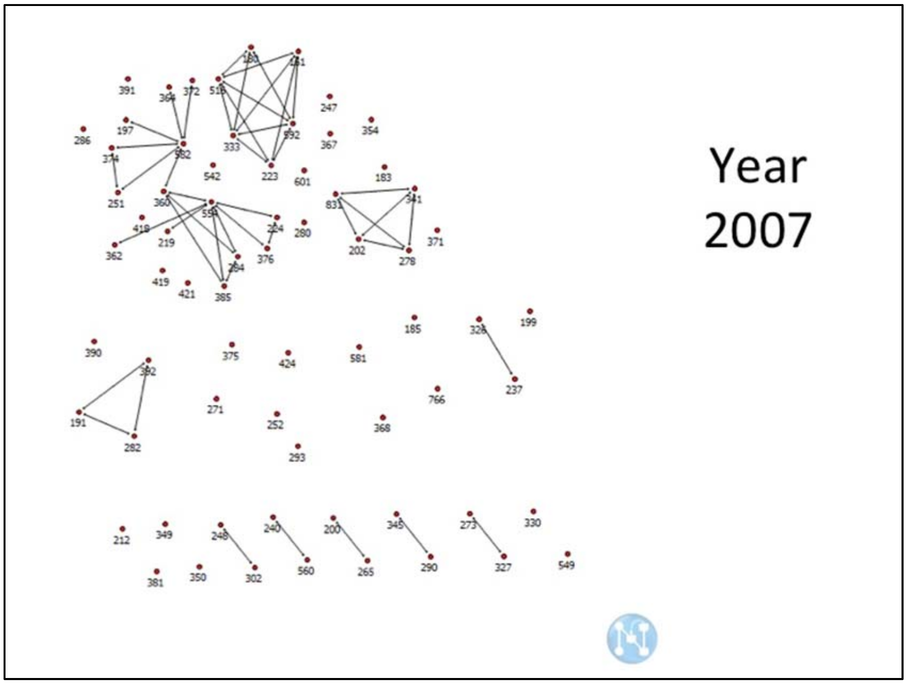
The findings of this research call attention to the role of environmental uncertainty in interdependent activities. The findings illustrate that the performance of interdependent organizations are susceptible to the performance shortfalls of their partners. While the results demonstrated statistical significance, closer examination of the data revealed that some programs appear to be more susceptible to their upstream partners than others. The examination of why some programs may be more susceptible to their partners was beyond the scope of this research. Given these results, why a given program may be more or less immune is, thus, a topic worthy of analysis.

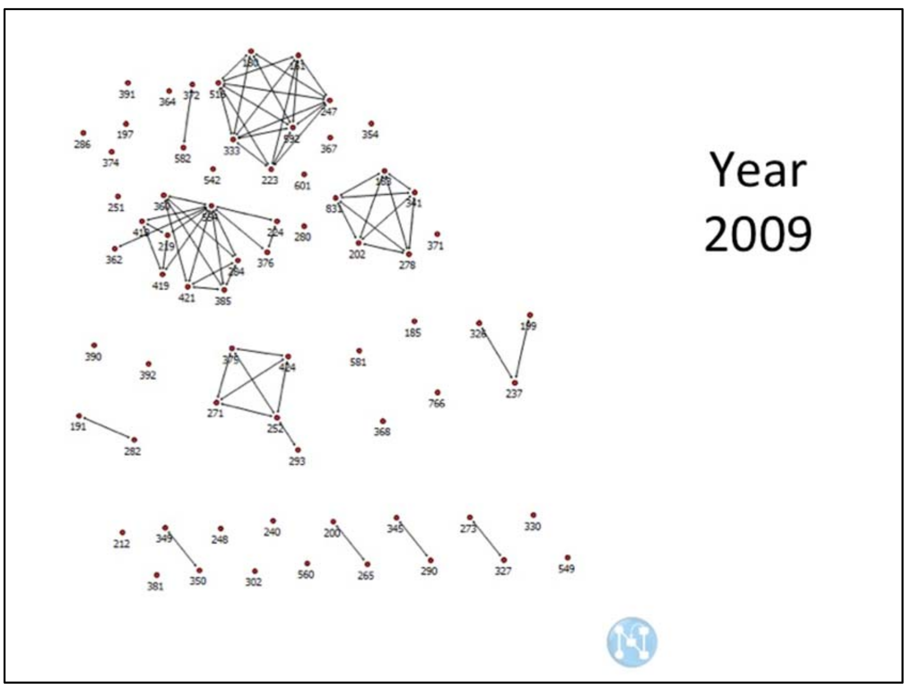
THIS PAGE INTENTIONALLY LEFT BLANK

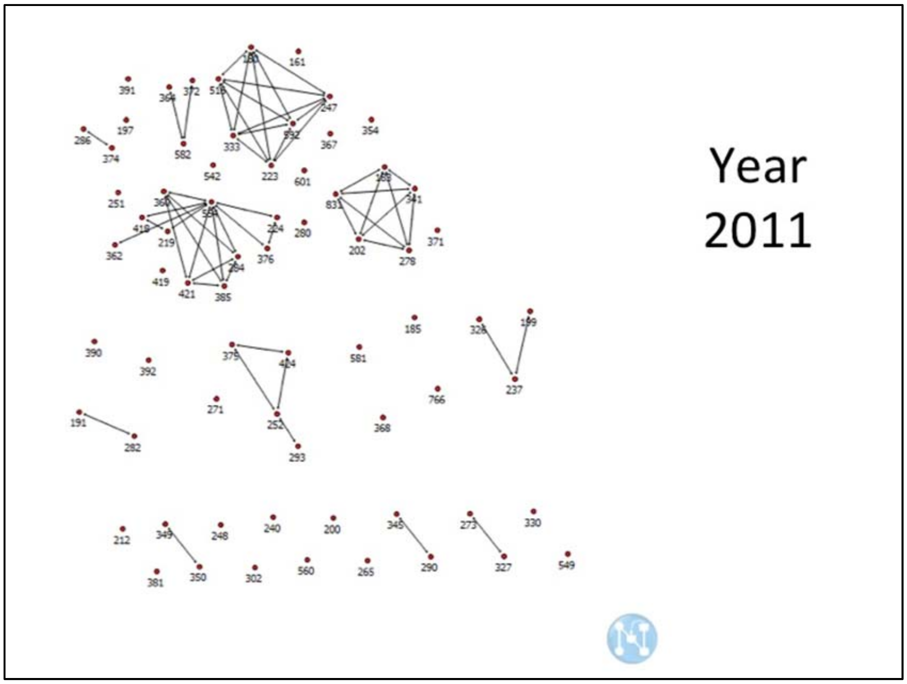
Appendix: Budget Sharing Networks Over Time






Year
2007


Year
2009


Year
2011

THIS PAGE INTENTIONALLY LEFT BLANK

List of References

Ansoff, H. I. (1979). *Strategic management*. London, UK: The MacMillan Press.

Cohen W. M. & Levinthal, D. A. (1990) Absorptive Capacity: A New Perspective on Learning and Innovation. *Administrative Science Quarterly*, 35,1 (128-152).

Comfort, L. (1994, September). Interorganizational learning following the Northridge earthquake of January 17, 1994. *Journal of Contingencies and Crisis Management*, *2*(3),174–188.

Cyert, R. M., & March, J. G. (1963/1992). *A behavioral theory of the firm* (2nd ed.). Englewood Cliffs, NJ: Prentice Hall.

Granovetter, M. (1973). The strength of weak ties. *American Journal of Sociology*, *78*(6), 1360–1380.

Grant, R.M. (1996). Toward a Knowledge-Based Theory of the Firm. *Strategic Management Journal* (17), 109–122.

Hall, C. C., Ariss, L., & Todorov, A. (2007). The illusion of knowledge: When more information reduces accuracy and increases confidence. *Organizational Behavior and Human Decision Processes*, *103*, 277–290.

Herbert, Simon (1969). *The Sciences of the Artificial*. MIT Press, Cambridge, Mass, 1st edition

Jones, C., Hesterly, W. S., & Borgatti, S. P. (1997, October). A general theory of network governance: Exchange conditions and social mechanisms. *The Academy of Management Review*, *22*(4), 911–945.

Kauffmann SA (1993) *The Origins of Order: self-organization and selection in evolution*, Oxford University Press, New York.

Lawrence, P. R., & Lorsch, J. W. (1967). *Organization and environment: Managing differentiation and integration.* Cambridge, MA: Harvard University, Graduate School of Business Administration, Division of Research.

Lawrence, P., and Lorsch, J., (1967), Differentiation and Integration in Complex Organizations. *Administrative Science Quarterly* 12, 1-30.

Levinthal, D. (1997). Adaptation on rugged landscapes. *Management Science, 43*(7), 934–950.

Levinthal, D., & Warglien, M. (1999). Landscape design: Designing for local action in complex worlds. *Organization Science*, *10*(3), 342–357.

March JG, Simon HA. (1958). *Organizations*. New York: Wiley

McPherson, J.M. and J. Ranger-Moore (1991). Evolution on a Dancing Landscape: Organizations and Networks in Dynamic Blau Space. *Social Forces*, 70:19-42.

Miles, R. E., & Snow, C. C. (1978). *Organizational strategy, structure, and process.* New York, NY: McGraw-Hill.

Miles, R. E., & Snow, C. C. (1992, Summer). Causes of failure in network organizations. *California Management Review*.

Miles, R. E., Snow, C. C., & Pfeffer, J. (1974). Organization-environment: Concepts and issues. *Industrial Relations*, *13*, 244–264.

Milliken, F. (1987). Three types of perceived uncertainty about the environment: State, effect, and response uncertainty. *Academy of Management Review*, *12*(1), 133–143.

Perry-Smith, J.E. and Shalley C.E. (2003) The Social Side of Creativity: A Static and Dynamic Social Network Perspective. *Academy of Management Review*, 28:1 (89-106).

Simon, H. A. (1973). Applying information technology to organizational design. *Public Administration Review*, *33*(3), 268–278.

Simon, H. A. (1976). *Administrative behavior. A study of decision-making processes in administrative organization* (3rd ed.). London, UK: The Free Press.

Sosa, M. 2011. Where do creative interactions come from? The role of tie content and social networks. *Organization Science*, 22(1):1-21.

Stacey RD. (2002). *Strategic management and organisational dynamics: the challenge of complexity*. 3rd ed. Harlow: Prentice Hall.

Thompson, J. D. (1967). *Organizations in action: Social science bases of administrative theory.* New York, NY: McGraw-Hill.

Thompson, J. D., (1967): *Organizations in Action*. New York: McGraw-Hill

Turner, J. (1988). *A Theory of Social Interaction*. Stanford University Press, Stanford, California.

Volberda, H. W., Foss, N. J., & Lyles, M. A. (2010). Absorbing the concept of absorptive capacity: How to realize its potential in the organization field. *Organization Science, 21*, 931–951.

Wasserman, Stanley, and Katherine Faust. 1994. *Social Network Analysis: Methods and Applications*. New York, NY: Cambridge University Press.

Williamson, O. E. (1981). The economics of organization: The transaction cost approach. *The American Journal of Sociology*, *87*(3), 548–577.

THIS PAGE INTENTIONALLY LEFT BLANK

2003 - 2012 Sponsored Research Topics

Acquisition Management

- Acquiring Combat Capability via Public-Private Partnerships (PPPs)
- BCA: Contractor vs. Organic Growth
- Defense Industry Consolidation
- EU-US Defense Industrial Relationships
- Knowledge Value Added (KVA) + Real Options (RO) Applied to Shipyard Planning Processes
- Managing the Services Supply Chain
- MOSA Contracting Implications
- Portfolio Optimization via KVA + RO
- Private Military Sector
- Software Requirements for OA
- Spiral Development
- Strategy for Defense Acquisition Research
- The Software, Hardware Asset Reuse Enterprise (SHARE) repository

Contract Management

- Commodity Sourcing Strategies
- Contracting Government Procurement Functions
- Contractors in 21st-century Combat Zone
- Joint Contingency Contracting
- Model for Optimizing Contingency Contracting, Planning and Execution
- Navy Contract Writing Guide
- Past Performance in Source Selection
- Strategic Contingency Contracting
- Transforming DoD Contract Closeout
- USAF Energy Savings Performance Contracts
- USAF IT Commodity Council
- USMC Contingency Contracting

Financial Management

- Acquisitions via Leasing: MPS case
- Budget Scoring
- Budgeting for Capabilities-based Planning
- Capital Budgeting for the DoD
- Energy Saving Contracts/DoD Mobile Assets
- Financing DoD Budget via PPPs
- Lessons from Private Sector Capital Budgeting for DoD Acquisition Budgeting Reform
- PPPs and Government Financing
- ROI of Information Warfare Systems
- Special Termination Liability in MDAPs
- Strategic Sourcing
- Transaction Cost Economics (TCE) to Improve Cost Estimates

Human Resources

- Indefinite Reenlistment
- Individual Augmentation
- Learning Management Systems
- Moral Conduct Waivers and First-term Attrition
- Retention
- The Navy's Selective Reenlistment Bonus (SRB) Management System
- Tuition Assistance

Logistics Management

- Analysis of LAV Depot Maintenance
- Army LOG MOD
- ASDS Product Support Analysis
- Cold-chain Logistics
- Contractors Supporting Military Operations
- Diffusion/Variability on Vendor Performance Evaluation
- Evolutionary Acquisition
- Lean Six Sigma to Reduce Costs and Improve Readiness

- Naval Aviation Maintenance and Process Improvement (2)
- Optimizing CIWS Lifecycle Support (LCS)
- Outsourcing the Pearl Harbor MK-48 Intermediate Maintenance Activity
- Pallet Management System
- PBL (4)
- Privatization-NOSL/NAWCI
- RFID (6)
- Risk Analysis for Performance-based Logistics
- R-TOC AEGIS Microwave Power Tubes
- Sense-and-Respond Logistics Network
- Strategic Sourcing

Program Management

- Building Collaborative Capacity
- Business Process Reengineering (BPR) for LCS Mission Module Acquisition
- Collaborative IT Tools Leveraging Competence
- Contractor vs. Organic Support
- Knowledge, Responsibilities and Decision Rights in MDAPs
- KVA Applied to AEGIS and SSDS
- Managing the Service Supply Chain
- Measuring Uncertainty in Earned Value
- Organizational Modeling and Simulation
- Public-Private Partnership
- Terminating Your Own Program
- Utilizing Collaborative and Three-dimensional Imaging Technology

A complete listing and electronic copies of published research are available on our website: www.acquisitionresearch.net

THIS PAGE INTENTIONALLY LEFT BLANK

ACQUISITION RESEARCH PROGRAM
GRADUATE SCHOOL OF BUSINESS & PUBLIC POLICY
NAVAL POSTGRADUATE SCHOOL
555 DYER ROAD, INGERSOLL HALL
MONTEREY, CALIFORNIA 93943

www.acquisitionresearch.net